1. SCOPE

This document describes the contents of the data portion of the first transfer frame output by the high rate telemetry board after it has been commanded by the IP or the camera to begin a data transfer. The data in the first transfer frame is neither packed nor compressed by the hardware. The intention of this aspect of the design is that the first transfer frame would be used to identify parameters associated with the [image] data to follow. The first 252 words of this data set come from the DEP or DSOS by way of the camera. The remaining words are inserted by the IP. Table 1 shows the general format of the first transfer frame. Detailed description of the subfields within the transfer frame and packet header sections appears in MDI330036 and in the CCSDS Packet Telemetry Blue Book (CCSDS 102.0.B-2).

BYTE(S)	DESCRIPTION	VALUE (HEX)
TRANSFER FRAME PRIMARY HEADER		
0 - 3	SYNC	352EF853
4 - 5	FRAME ID	0154
6	MASTER CHANNEL FRAME COUNT	XX
7	VIRTUAL CHANNEL FRAME COUNT	XX
8 - 9	FRAME DATA FIELD STATUS	1800
MDI PACKET HEADER		
10 - 11	PACKET IDENTIFICATION	80C4
12 - 13	PACKET SEQUENCE CONTROL	YXXX (Y=11xx)
14 - 15	PACKET LENGTH	044E
SOURCE DATA FIELD		
16 - 19	PROCESSING IDENTIFICATION	P00000NK †
20 - 521	CAMERA HEADER DATA FIELD (See Tables 2-1 through 2-6)	
522 - 1118	IMAGE PROCESSOR HEADER FIELD (See Table 3-1)	

† P: 0 = FILL MODE
4 = COMPRESSED MODE
8 = COMPACTED MODE
C = RAW DATA
NK: COMPRESSION PARAMETERS (4 bits each)

Table 1 Format of Transfer Frame 1

2. BACKGROUND

The following facts are useful for understanding the ideas behind the content of the header.

2.1. DEP/CCD INTERFACE

The DEP CCD camera interface electronics includes 256 bytes of memory available for Image Processor (IP) control information and frame annotation. This memory is in two 128 byte sections. (In truth, there are 4 memory sections; the other 2 are dedicated to readout maps that control camera summing modes). Each section can be addressed randomly, i.e. the DEP can select a particular byte and set a new value to that byte only. The camera receives an entire 128 byte section upon a specific command from the DEP to the interface.

2.2. BYTES → PIXELS → WORDS

Header data is transferred from the DEP to the camera as bytes. The header is output from the camera to the IP as any other data, i.e., 12 bit "pixels". The IP interface puts these data into IP memory as 16 bit words. For the rest of this discussion, the 8 bit byte is the basic telemetry data entity (primarily because the transfer frame is an odd number of bytes long); however, because of the architecture, only 8 bits of every 16 bits of camera header contains useful information. Discussions about data processing internal to the image processor will sometimes refer to 16 bit words. I hope this doesn't cause too much confusion.

The first 4 words of the camera header are used by the DMA interface to route the remaining camera data to memory. During this process, those words are consumed by the interface and forever lost. From a telemetry standpoint, there are 504 bytes of camera header data. (Once again a reminder that only the lower 8 bits of each word contains data that originated in the DEP).

2.3. DATA PRODUCTS

The telemetry board outputs data from one or two pages upon a command from either the IP or the camera. For this discussion the term "Data Product" describes the data in one (of these) pages.

2.4. CAMERA/TELEMETRY MODES

There are 3 modes by which high rate data can appear at the telemetry interface: DEP-IP mode (normal), DSOS mode, and DEP-TM mode. In the first mode, the IP executes an instruction that outputs 1 or 2 pages to the interface. In the last two modes, data is routed directly to the interface by information at the beginning of the camera header. In normal mode, the length of each data product is determined by image processor can be less than a full page, while in the other modes, data products are restricted to full pages, unless the data flow is interrupted by a new frame. Regardless of mode, the telemetry board does no compression or packing of the first transfer frame (1109 bytes total, 1099 bytes of data).

2.5. CAMERA HEADERS

In DSOS and DEP-TM mode, a camera header appears automatically with each high rate data product (observable) simply because the header is output first by the camera and thus goes to the start of the memory page that will be sent to the telemetry board.

In IP mode, a camera header appears with every data product by convention only, i.e., program executing in the IP must contain instructions to get the header data to the telemetry board. Nothing about this process is automatic. A data product is typically the result of processing many individual frames, e.g. a dopplergram, magnetogram, packed set of filtergrams, etc. Twenty or so frames are typically taken during a minute observing cycle, and only one or two data products are produced during the cycle. The onus is on an IP program invoked during the cycle not only to process the camera data into data products, but also to get the correct header information to the start of the memory page(s) that contain(s) the data product.

3. REQUIREMENTS

The following list contains the "requirements" used to determine the content and structure of the header.

3.1. IMAGE PROCESSOR PARAMETERS

3.1.1. REQUIREMENT

The header must contain information that can be used by the Image Processor to control processing flow or supply parameter value(s) to certain instructions.

3.1.2. IMPLEMENTATION

The DEP general purpose registers are included in the header, allowing the IP to use DEP supplied image processing information synchronized to the data frame.

3.2. DATABASE ASSOCIATION

3.2.1. REQUIREMENT

There must be a mechanism by which ground based software can associate high rate telemetry data products to a sequence

3.2.2. IMPLEMENTATION

The DEP supplied sequence (or frame) identifier allows ground based software to associate the data product with the sequence database.

3.3. CORRELATION TO HOUSEKEEPING DATA

3.3.1. REQUIREMENT

There must be a mechanism to correlate high rate telemetry to housekeeping telemetry.

3.3.2. IMPLEMENTATION

The housekeeping packet number at the reference time is included in the header. In addition, the header data includes the lower 8 bits of the housekeeping packet number at the time of each frame. This same parameter appears in the housekeeping data stream.

3.4. QUICK-LOOK FRAME VERIFICATION

3.4.1. REQUIREMENT

The header must supply enough information for ground processing software to verify the basic validity of the data product.

3.4.2. IMPLEMENTATION

The DEP supplied portion of the header contains temperature, front door, alignment mechanism, calibration wheel position, and limb tracker status telemetry. In addition, there is a status byte for each frame indicating errors that have occurred during the frame.

3.5. IMAGE PROCESSOR STATUS INFORMATION

3.5.1. REQUIREMENT

The header must supply information about the Image Processor status and configuration that may be required for correctly analyzing the data product.

3.5.2. IMPLEMENTATION

The header contains a data product identifier that is inserted by the IP by IP instruction. In addition, the 256 general purpose IP registers are included in this section of the header. (There are additional words available in this field that may be defined later).

3.6. FORMAT CONTINUITY

3.6.1. REQUIREMENT

The basic header format must be the same in all modes. There must be mechanisms by which data products taken in sequences can be distinguished from data taken by telecommand, and by which data products processed by the IP can be distinguished from those not processed by the IP.

3.6.2. IMPLEMENTATION

In normal mode, the DEP (or DSOS) supplied portion of the header is not packed by the IP even though that data occupies only the lower 8 bits of each 16 bit field. The IP supplies a "sync" pattern in its portion of the data to readily identify the data product as having been processed by the IP. The DEP differentiated sequence data from data taken by telecommand using the lower (otherwise unused) bits of the reference time.

4. CAMERA HEADER DESCRIPTION

4.1. FORMAT DESCRIPTION

Table 2-1 shows the camera header as it appears on telemetry, i.e. the 4 words (8 bytes) that the IP swallows are not shown and the header is 504 bytes long. Every other byte contains valid data.

ITEM	LENGTH		START		DESCRIPTION
	BYTES	WORDS	BYTES	WORDS	
CONTROL	10	5	0	0	Image Processor Control Words
SEQUENCE INFORMATION					
REGS	64	32	10	5	DEP Sequence Control Registers *
SQID	8	4	74	37	Sequence or Frame Identifier *
SQNUM	4	2	82	41	Sequence Number *
SQFRM	4	2	86	43	Frame Number in this sequence *
REFTIME	12	6	90	45	Reference Time
RSTRT	4	2	102	51	DEP Restart Number
FRMNUM	8	4	106	53	Frame Number
HKPACK	8	4	114	57	Housekeeping Packet Number
DEPVR	4	2	122	61	DEP Software Ver(maj.min)
OCTVR	4	2	126	63	Optics Configuration Table Ver (maj.min)
SEQVR	4	2	130	65	Sequence Version Number (maj.min)
IPVR	4	2	134	67	IP Firmware Version Number (maj.min)
QUEUEVR	4	2	138	69	Instruction Queue Ver(maj.min)
ALIGN	8	4	142	71	Position of the alignment Mechanism
C1POS	2	1	150	75	Position of Calibration Wheel #1
C2POS	2	1	152	76	Position of Calibration Wheel #2
MISCSTAT	2	1	154	77	Miscellaneous status bits
LTERRS	8	4	156	78	Limb Tracker Errors(Xmax, Xave, Ymax, Yave)
LTSTAT	2	1	164	82	Limb Tracker Status Word
HTRSTAT	8	4	166	83	Heater Status Words
OVNTEMP	4	2	174	87	Oven Temperatures (OPTS 4 and 5)
OPTEMPS	4	2	178	89	Optics Package Temperatures (TBD)
CCDTEMPS	40	20	182	91	10 CCD temperatures
SPARE1	24	12	222	111	Allocated for possible expansion
FRAME INFORMATION (SECOND DEP BUFFER)					
NFRAMES	2	1	246	123	Number of valid frame definitions
SPARE2	14	7	248	124	Allocated for possible expansion
HKPACK1	2	1	262	131	HK Packet # for frame 1 (lower 8 bits)
FRSTAT1	2	1	264	132	Status information on frame 1
SPARE3	4	2	266	133	Allocated for possible expansion
ETC	†	†	270	135	4 bytes for each frame (up to 30 total)

* These labels are valid only for frames taken is sequence mode. In telecommand mode they can be loaded via command MBCMHDRX (X=1 or 2).
† 4*(NF-1) words or 8*(NF-1) bytes

Table 2-1 Camera Header

4.2. ITEM DESCRIPTIONS

4.2.1. CONTROL

The following block shows the format of the control words section of the header. See MD330037 for a detailed description of the items in the control block.

BYTES	MSB								LSB
	15.....8	7	6	5	4	3	2	1	0
0 - 1		PG ADR1		PG ADR2		1/2		TEL CMD	
2 - 3							IFC CMD		
4 - 5									
6 - 7		QUEUE ADDR (low byte)							
8 - 9		QUEUE ADDR(high byte)							

Table 2-2 Image Processor Control Words

4.2.2. SEQUENCE INFORMATION

4.2.2.1. REGS

For frame taken in sequence mode, these bytes contain the 16 DEP general purpose sequence control registers. In telecommand mode these bytes are meaningless unless loaded via telecommand prior to time the frame is taken.

4.2.2.2. SQID

These bytes contain the Sequence Identifier as set by DEP sequencer instruction (SID). In telecommand mode these bytes are not meaningful unless loaded via telecommand prior to time the frame is taken.

4.2.2.3. SQNUM

These bytes contain a number incremented by the DEP each time a new sequence is started. In telecommand mode, these bytes may not be meaningful.

4.2.2.4. SQFRM

These bytes contain a number incremented by the DEP each time a frame is taken are reset whenever a new sequence is started. In telecommand mode, these bytes may not be meaningful.

4.2.2.5. REFTIME

Camera headers include a field labeled reference time. This field is 6 bytes long and contains a local on-board time. For telecommand frames, this is the LOBT at the time the DEP begins to process a take reference picture command (MBCMTP1R, MBCMTP3R, or MBCMDRKR). For sequence frames, this is the LOBT at the time the DEP Sequence Control Routine (SCR) executed the most recent Set Reference Time (SRT) instruction. It is not the reference time itself. The reference time is the nearest whole minute after this time. The low order bits of LOBT are not used, i.e. LOBT is a 43 bit time in a 48 bit field. The DEP uses these bits for frame status as defined in the following table.

Bit	State	Meaning
0	0	Frame taken by sequence
	1	Frame taken by telecommand
1	0	Dark frame
	1	Shutter controlled frame
2	0	1X exposure
	1	3X exposure

Table 2-3 Reference Time Status Bits

4.2.2.6. RSTRT

During operations, the DEP may require a restart, because of either spacecraft or MDI problems. Many counters such as the frame counter would become not unique. Restart number is a parameter designed to restore uniqueness to various counters and identifiers. Restart number is incremented each time the DEP is reset. Restart number must be managed by ground based software. The detailed mechanism for updating the restart number in the DEP is TBD.

4.2.2.7. FRMNUM

This parameter is updated each time a frame of any type is taken. There is no mechanism for resetting its value other than resetting the DEP or using the general purpose memory load command.

4.2.2.8. HKPACK

This parameter contains the housekeeping packet number. The housekeeping packet number is updated each time a housekeeping packet is sent to the interface. The same number appears in housekeeping telemetry. Because housekeeping and high rate telemetry are both buffered and buffered asynchronously by different processors, one can only say that HKPACK contains the number of the packet most recently passed to the DEP telemetry interface at the time the DEP sequencer executed a reference time instruction.

4.2.2.9. DEPVR

These bytes contain the DEP software version number in the form of major.minor version. Management of version number is a ground based function. The mechanism by which version numbers are updated is TBD.

4.2.2.10. OCTVR

These bytes contain the DEP Optics Configuration Table version number in the form of major.minor version. Management of version number is a ground based function. The mechanism by which version numbers are updated is TBD.

4.2.2.11. SEQVR

These bytes contain the DEP Sequence List version number in the form of major.minor version. Management of version number is a ground based function. The mechanism by which version numbers are updated is TBD.

4.2.2.12. IPVR

These bytes contain the Image Processor firmware version number in the form of major.minor version. Management of version number is a ground based function. The mechanism by which version numbers are updated is TBD.

4.2.2.13. QUEUEVR

These bytes contain the Image Processor Instruction Queue version number in the form of major.minor version. Management of version number is a ground based function. The mechanism by which version numbers are updated is TBD.

4.2.2.14. ALIGN

The 10 bit positions of each of the leg potentiometers are reported in these bytes.

WORD	DESCRIPTION
67	AM1 BITS 9-8 (Right Justified)
68	AM1 BITS 7-0
69	AM2 BITS 9-8 (Right Justified)
70	AM2 BITS 7-0

Table 2-4 Alignment Mechanism Data Format

4.2.2.15. C1POS

The eight bit position of calibration wheel 1 is reported in this byte.

4.2.2.16. C2POS

The eight bit position of calibration wheel 2 is reported in this byte.

4.2.2.17. MISCSTAT

The miscellaneous status byte conatins a copy of housekeeping telemetry word 21 as described in table 2-5. Description line for each bit is the housekeeping mnemonic with the leading MK removed. Refer to MDI Housekeeping Telemetry Description (MD330039) for mnemonic definitions.

BIT	7	6	5	4	3	2	1	0
	TMSEL	PWHRO	PWHCM	LTLOOP	FDOPN1	FDOPN2	FDMTR1	FDMTR2

Table 2-5 Miscellaneous Status Monitors

4.2.2.18. LTERRS

The four limb tracker parameters shown in these four bytes are copies of the housekeeping values, i.e., there are housekeeping maximum and average values rather than the average and value since the previous high rate telemetry report.

4.2.2.19. LTSTAT

This byte contains the most recent limb tracker status word reported to housekeeping.

4.2.2.20. HTRSTAT

These bytes contain copies of four heater status housekeeping monitors. These are Optics Package Heater Controller (MUHOPCTL), Filter Oven Bridge Out (MHHPOBRG), Filter Oven Loop Out (MUHPOLOP), and Filter Oven Redundant Controller (MUHROCTL).

4.2.2.21. OVNTEMP

These byte contain the Optics Package Temperature monitors that represent the temperature of the filter oven (MTOPTS4 and MTOPTS5).

4.2.2.22. OPTEMP

Two additional optics package temperature monitors appears in these bytes. Monitor selection is TBD.

4.2.2.23. CCDTEMPS

The DEP periodically acquires camera temperatures from the IP. There are 10 such temperatures available. Each is sampled 32 times by the camera electronics. The DEP periodically instructs the IP to average these temperatures and return the results to the DEP. The DEP reports all temperatures in housekeeping and in this header. Temperatures are 10 bit digital values; so, 2 header words are required for each. The 10 bits are arranged in the same manner as the 10 bit alignment mechansism positions (See table 2-4). These data are valid only in frames processed by the IP.

4.2.2.24. SPARE1

These bytes are currently unassigned and reserved for future expansion.

4.2.3. FRAME INFORMATION

This section of the camera header contains status information about each frame as it is taken.

4.2.3.1. NFRAMES

This byte contains the number of frame status doublets that follow that follow.

4.2.3.2. SPARE 2

These bytes are currently unassigned and reserved for future expansion.

4.2.3.3. HKPACK

This byte contains the lower 8 bits of the housekeeping packet number which contains the detailed status information about this frame.

4.2.3.4. FRSTAT

The frame status byte for each frame (FRSTAT in the header description table is defined as follows:

BIT	7	6	5	4	3	2	1	0
	M1ERR	M2ERR	PAWERR	C1ERR	C2ERR	LTERR	FRERR	MINMRK

Table 2-6 Frame Status Byte

In table 2-6 a 1 indicates the following conditions occurred between this frame and the previous frame:

- MINMRK LOBT passed through an integer minute
- FRERR At least one time tagged sequence instruction executed late
- LTERR At Limb Tracker error of some sort occurred
- C1ERR CAL1 positioning error occurred
- C2ERR CAL2 positioning error occurred
- PAWERR PAW positioning error occurred
- M1ERR MTM1 positioning error occurred
- M2ERR MTM2 positioning error occurred

4.2.3.5. SPARE 3

These bytes are currently unassigned and reserved for future expansion.

4.2.3.6. ETC.

The above 4 words are repeated NFRAMES-1 times,

4.3. IMAGE PROCESSOR DATA FIELD

Regardless of mode, the telemetry board does no compression or packing of the first transfer frame (1099 bytes of data). The header described so far occupies 504 bytes (252 words). The next 594 bytes (297 words) contains data produced by the IP as a function of executing the program that creates the data products. The last byte of the frame is forced to 0 by the hardware. The table 3-1 shows the format of these data.

ITEM	LENGTH		START[1]		DESCRIPTION
	BYTES	WORDS	BYTES	WORDS	
SYNC	4	2	502	251	DBE128BD (hex)
DPC	4	2	506	253	Data Product Code
IPREG	512	256	510	255	IP General Purpose Registers
SPARE	76	38	1022	511	Spare
LASTBYTE	1	-	1098	549	Forced to zero by the hardware.

Table 3-1 Image Processor Header Data Field

[1]The 0 of this field is byte 20 of the transfer frame, bytes 0-19 being generated by the hardware.